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Title: Solar Flare Forecasting Using Topological Energy Models

Abstract: This is a proposal to develop tools for forecasting the severity of solar storms initiated from magnetic regions. The most severe storms occur when magnetic energy stored in these so-called active regions is suddenly converted to other forms such as radiation and outward moving material. Solar scientists still do not understand enough of the relevant physics to predict the instant this conversion will occur or the severity of the storm's effect on Earth. With the present understanding, however, it is possible to estimate the amount of energy currently stored in each region present, and how much of this energy is ready for release. This grant would fund the development of a set of programs to make such energy estimates continuously using routine photospheric magnetograms. The estimate is based on a simplification of the full set of magnetohydrodynamic equations known as the Minimum Current Corona, which places a rigorous lower bound on magnetic energy stored by slow motions of the complex photospheric field to which it is anchored. The energy is stored as field lines anchored to different photospheric regions interact with one another. This proposal would develop the methods for automatically identifying all photospheric regions and quantifying their sizes, locations and internal and external motions. These are translated into an energy estimate under the assumption that no reconnection occurs between field lines anchored to different regions. These steps are computationally simple enough to be performed continuously, automatically, in real time on a small computer. It is then possible to estimate the energy which would be released when any set of field lines were to reconnect at that instant. Such hypothetical reconnection scenarios can also be characterized by the amount of twist (helicity) which would be present in magnetic field ejected from the Sun --- a quantity which may be significant in predicting the consequences at Earth of the solar eruption. At the end of the funding the methods will be tested using observations of past flares, and then made publicly available. Since it delivers a method and software implementation useful in forecasting solar activity, this project is well suited to the Tools and Methods component of the Targeted Research and Technology program.